BRINGING THE FUTURE SPACE BASED INFRA RED SYSTEMS TO THE WARFIGHTER

Captain Ann Wong-Jiru
SMC/MTEP, 185 Discoverer Blvd, Suite 2512, LAAFB, El Segundo CA, 90245-4695
Email: Ann.Wong-Jiru@losangeles.af.mil

Mr. Brad Kettner, SPARTA, Inc.
JNTF/RDC, 720 Irwin Avenue, Schriever AFB CO 80912-7200
Email: bkettner@jntf.osd.mil

Charlotte Scharer
JNTF/WMM, 730 Irwin Avenue, Schriever AFB CO 80912-7300
Email: cscharer@jntf.osd.mil

Abstract

The Space Based Infra Red System Wargaming Model (SBIRS/WM) is a simulation representing the future SBIRS capabilities for the Space and Missile Systems Center SBIRS Program Office, Advanced Program Division (SMC/MTEP) in wargames and exercises. SBIRS/WM is required to run in real-time utilizing various interfaces and protocols, and can be used to perform design trades, refining requirements, and providing an independent tool for verification of system operational utility and effectiveness. SBIRS/WM is based on current operational requirements, and currently represents SBIRS in Joint National Test Facility (JNTF) wargames, other system-of-system simulations, and exercises. The simulation represents Low Earth Orbit (LEO), Geostationary Earth Orbit (GEO), and Highly Elliptical Orbit (HEO) elements of the program. The JNTF has teamed with SMC, the SBIRS Contractor, and the Software Engineering Institute to evolve SBIRS/WM to meet current and future needs, and to evaluate Product Line Architecture (PLA) applicability to conducting business. The initial product will be called the Missile Defense Space Tool (MDST), and will initially be used to support Expeditionary Forces Experiment 1998. This paper describes the SBIRS system and concepts, and then describes how the JNTF and SMC will bring that concept to the warfighter in the form of a flexible and realistic simulation tool.

The Warfighter Need for SBIRS

In order to provide warning of a first strike attack by the Soviet Union, the United States constructed a vast network of surveillance posts, radar sites, and satellite systems. One of these systems was a constellation of infrared satellites in geostationary orbit called the Defense Support Program (DSP). First launched in 1970 and still operational today, DSP's primary mission is to detect rockets in their boost phase and to report them to the National Command Authority.

As the Cold War ended, missile threats and challenges changed. Instead of a mass ICBM strike from the USSR against the U.S. mainland, tomorrow's threats come primarily from potential rogue nations and terrorist groups that have acquired theater and ballistic missile technology with nuclear, chemical and biological warheads. An ICBM attack from former Soviet Republics or China is still possible, so we must still maintain the capability to provide early warning against ICBM attacks. With the threats to U.S. forces evolving, so too must the weapon systems used to combat them.

The Missions

In order to meet the needs of future conflicts, four primary missions have been allocated to SBIRS.

1. Missile Warning: Utilizing over 25 years experience on DSP and state-of-the-art technology, missile warning capabilities will significantly increase, and space based platforms will provide better missile warning information to commanders.

2. Missile Defense: This mission will be satisfied by using space based infrared platforms to track targets from initial boost phase through mid-course, and this data will be relayed to interceptors.

3. Technical Intelligence: Using multiple platforms, space based infrared sensors will provide valuable data necessary for missile characterization, phenomenology and other target data.

4. Battlespace Characterization: Capitalizing on the advantages of space based infrared sensors, commanders will be able to assess battle damage and track infrared-intense events to improve battlefield situational awareness.

SBIR System Overview

The answer to the evolving threats and the four missions is the Space Based Infra Red System (SBIRS) architecture. This new system, currently under development, is a "System of Systems" approach that will integrate space assets in multiple orbit configurations with a consolidated ground segment to provide more effective integration of data and better information to the warfighter. The goal is to provide a seamless transition from DSP to SBIRS and meet the jointly defined requirements of the entire defense community using streamlined acquisition processes and capitalizing on mature technologies.

The SBIRS architecture is not a revolutionary idea. It is instead an evolutionary step forward in space based infrared surveillance. The SBIRS architecture (Figure 1) will consist of the existing DSP satellites, four GEO satellites, two HEO satellites, a constellation of greater than 20 LEO satellites and a ground processing element to provide global coverage in support of the SBIRS missions.

The SBIRS ground segment will be implemented beginning in calendar year 1999. Currently under development, a follow-on program to DSP called "SBIRS High" is scheduled for first launch in 2002. Completing the architecture, a new Low Earth Orbiting element called "SBIRS Low" will be added to the SBIRS architecture in 2004 (Figure 2). Consequently, current exercises and simulations are in need of a simulation tool that can realistically represent the near-future SBIR System. This simulation tool must also be able to evolve and transition in parallel with the operational SBIR System.

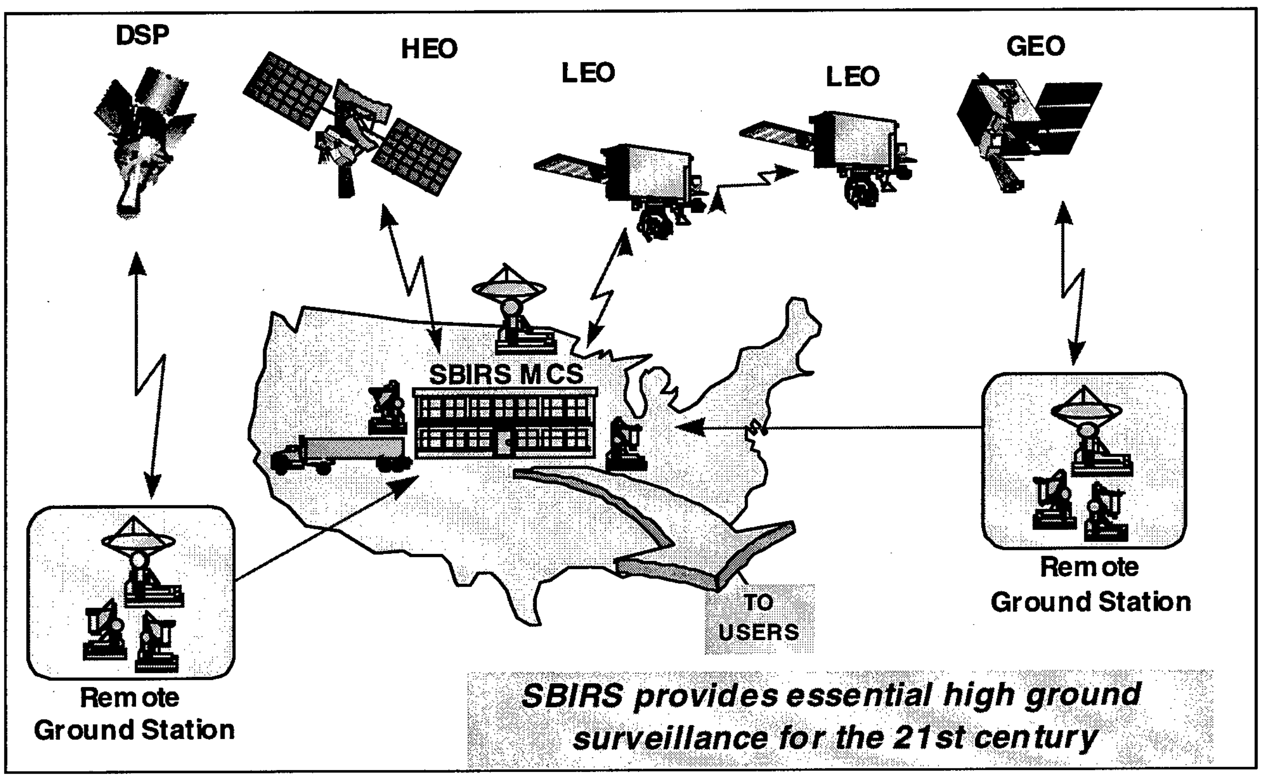

Figure 1. SBIRS A System of Systems

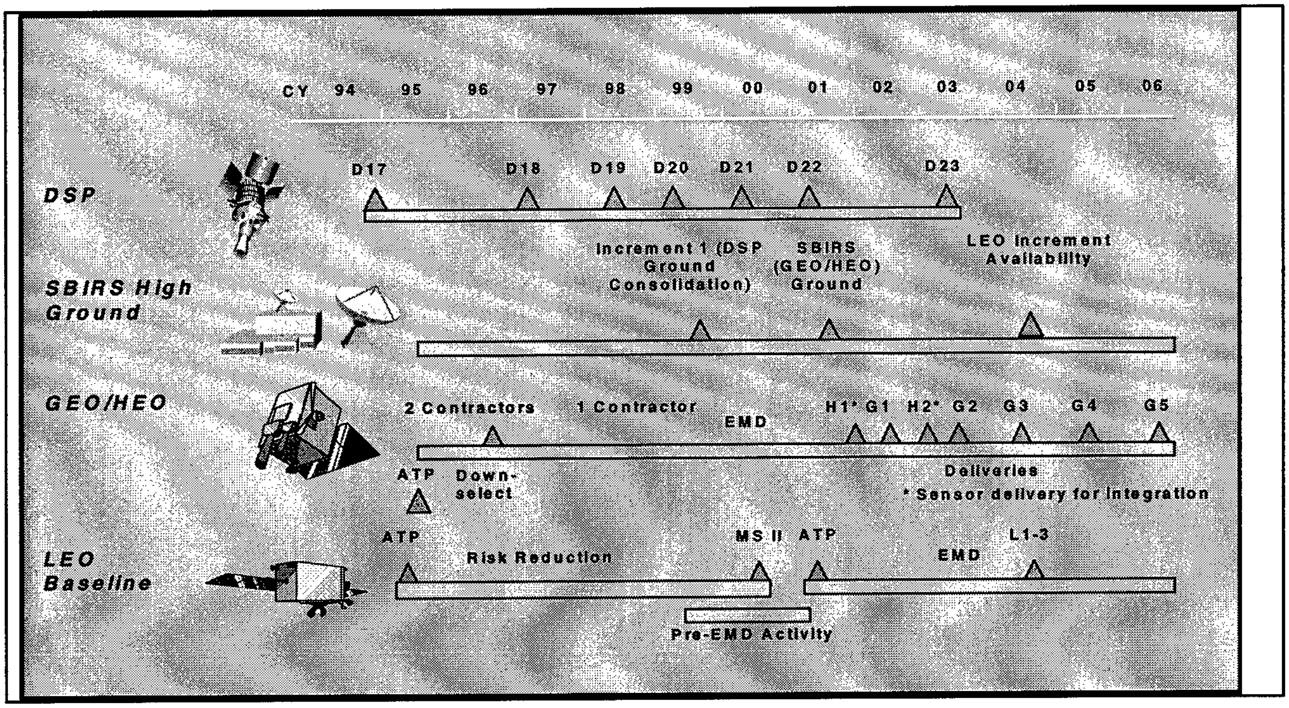

Figure 2. SBIRS Development Timeline

SBIRS DSP Segment

The DSP system consists of several satellites in geostationary orbit, an Overseas Ground Station (OGS) in Australia, a European Ground Station (EGS), a CONUS Ground Station (CGS) and Mobile Ground Terminals (MGT). Each satellite has the capability to view nearly an entire hemisphere of the earth and can detect missile launches from any location within its field of view. The satellites use a spinning motion to sweep its infrared detector arrays across the earth's surface to detect the hot missile plumes of boosting missiles. The data collected during these sweeps is relayed down to one of the three Air Force ground stations or MGTs around the world and then communicated to the National Command Authority or to commanders in the field. Data can also be received at the contractor's operations center. Alternately, U.S. and Allied forces deployed overseas can receive data directly from orbiting DSP satellites using the JTAGS system. There are five more satellites in the series that are scheduled to be launched between 1997 and 2003. The new SBIRS architecture will enter service during this time with improved capabilities to ensure there won't be any gap in our nation's early warning capability into the next century.

Talon Shield/ALERT

Talon Shield was originally conceived from lessons learned during Desert Storm. Talon Shield's tasks were to improve the existing theater warning capabilities of DSP and to find better ways of processing and disseminating crucial information to tactical users worldwide. These goals were achieved by significantly improving integration and processing of raw data from the entire DSP constellation at one location. On 30 September 1994, Talon Shield Phase 1 officially transitioned to the Attack and Launch Early Reporting to Theater (ALERT) system of the 11th Space Warning Squadron (SWS) under the 21st Space Wing. Using existing sensors and data collection sources, global data related to theater missile warning is transmitted to the ALERT and Shield systems located at the Joint National Test Facility at Schriever AFB, CO. Other communication resources are also integrated to facilitate information relay. The Central Tactical Processing Elements (CTPE) are the mission data processors that produce timely and accurate warning and cueing reports, which are then disseminated to warfighters worldwide by existing communication networks dedicated to tactical applications. The Central Theater Processing Program (CTPP) is the effort that supports the ALERT, Shield and Initial Qualification Training (IQT) processing elements. ALERT is the only component of the Tactical Event System that

monitors all Major Regional Conflict and Rest of World areas simultaneously. Its current features include worldwide data coverage from a full DSP constellation augmented by other data sources and fusion of data at the sensor level from multiple real-time sources utilizing an open system architecture using modern, commercial equipment. ALERT will continue operating until the SBIRS Ground Processing Increment 1 Initial Operating Capability (IOC) is achieved in late 1999. The Shield/ALERT development will continue to pave the way for the follow-on SBIRS ground system.

Joint Tactical Ground Station

The U.S. Army and Navy Joint Tactical Ground Station (JTAGS) is capable of receiving data from DSP satellites directly in a combat area and has been operational since early 1997. JTAGS is also capable of relaying processed, real-time information through communications networks to forces within theater. The JTAGS mission is to provide attack warnings to theater commanders so that appropriate firepower can be utilized to eliminate the immediate threat and to deter further aggression. Antimissile batteries to receive incoming missile warning messages and to point their radar systems in the proper direction can use JTAGS. The JTAGS system will be upgraded to accept data from the SBIRS satellites when they become operational in FY 2002.

SBIRS High

The SBIRS High component will use state of the art, highly flexible, tasking infrared sensor technology to combat emerging threats. This technology will allow the SBIRS High element to detect and track short range missiles with greater accuracy. The benefit to the warfighter will be improved missile launch point and impact point predictions in support of offensive and defensive operations, as well as reduced impact and disruption to the fighting readiness of deployed forces.

The SBIRS High component will feature a mix of four satellites in Geostationary Earth Orbit (GEO), two satellites in Highly Elliptical Orbit (HEO) and ground assets which include the following: a CONUS-based Mission Control Station (MCS), a backup MCS, a survivable MCS; overseas Relay Ground Stations; Relocatable Terminals; and associated communications links.

The GEO payload will use a scanning infrared sensor for rapid global coverage and a staring sensor for accurate theater detection and tracking. The SBIRS High Ground Segment will consolidate three DSP operational sites and associated communication networks into a fully integrated ground segment that fuses all infrared and other data to optimize performance for all infrared missions. The integrated ground segment will be implemented with modern, open systems processing and allow for modular hardware/software updates and appropriate use of commercial products.

SBIRS Low

The SBIRS Low component will bring an entirely new capability to the warfighter — the ability to track missiles from launch to re-entry and to relay necessary cueing data to missile interceptors before the missiles reach friendly forces. When fully operational, the SBIRS Low component will consist of greater than 20 satellites in Low Earth Orbit and will work in conjunction with SBIRS High to provide full global coverage. The primary function of SBIRS Low is to provide precise mid-course tracking and discrimination of objects for the SBIRS missile defense mission in theater conflicts and attacks against North America. In addition, with its low altitude putting it physically closer to the battlefield and thus allowing for higher resolution, the SBIRS Low program is well suited to enhance the other three SBIRS missions of missile warning, technical intelligence and battlespace characterization.

Each satellite will contain two infrared sensors to perform its missions. One sensor, known as the Acquisition Sensor, will be a wide field of view scanning infrared sensor utilizing short wave infra red (SWIR) technology to watch for bright missile plumes during boost phase. Once the Acquisition Sensor has located a target, that information is transferred to the second on board sensor, known as the Track Sensor, which has a narrow field of view, high precision staring infrared sensor. Mounted on a two-axis gimbal, the Track Sensor will be capable of locking onto a target and following it through its mid-course trajectory and into its re-entry phase. By this time, the on-board processing will have predicted the final missile trajectory and warhead impact point. This data will then be relayed to interceptor batteries where it will be used to intercept the incoming missile or warhead.

In addition, the entire constellation will be networked together using inter-satellite crosslinks, thus allowing each satellite to communicate with all other satellites in the constellation. This allows for spacecraft-to-spacecraft "handover" of target tracks. In other words, if satellite "A" is tracking a missile and the target is leaving the field of view of satellite "A," then that satellite can crosslink to satellite "B" and tell it where to look for the target. Then satellite "B" can continue the tracking function and provide the necessary cueing information to interceptor batteries. If necessary, this type of handover will continue between satellites of the constellation until the target has been destroyed or its infrared energy can no longer be detected.

Utilizing tracking data from SBIRS Low, the area defendable by a single interceptor battery increases dramatically. Whereas systems like the Patriot require that the missile be within view of its ground based radar before it can fire, SBIRS Low will provide cueing information to interceptors while warheads are still far away from friendly forces. This cueing information allows for multiple interceptor attempts on incoming missiles to increase the likelihood of a successful kill. SBIRS Low will "bridge the gap" between initial launch detection and Ground Based Radar interceptors.

Current Exercise Environment

The SBIRS Program office and Joint National Test Facility (JNTF) have been actively involved in many wargames and exercises, helping to define the Ballistic Missile Defense Organization's (BMDO) national missile defense (NMD) concepts of operations (CONOPS) and educating warfighter's on SBIRS's improved support to the warfighter. Among the events are C2 Sim exercises at the Joint National Test Facility, Warrior Flag '97, Roving Sands '97 and '98, and Joint Project Optic Windmill-3 (JPOW). The jointly developed SBIRS/WM software was used to support these activities. SBIRS/WM interactively provides SBIRS sensor data in support of the Command and Control simulations conducted at the JNTF, and plays a significant role in evaluating the future NMD CONOPS. Additionally, SBIRS/WM utilizes a Distributed Interactive Simulation (DIS) protocol to support theater and CINC exercises such as Roving Sands. SBIRS/WM uses the DIS network to participate in a listen only mode (does not provide sensor data to the participants). This approach allowed SMC to demonstrate the value of the SBIR System to the warfighters supporting these activities.

While conducting JPOW, the SBIRS/WM software displays were used to support verbal early missile warning. This was the first time that SBIRS/WM was used in a CINC exercise to support early warning. Additionally, Expeditionary Forces Experiment 1998 (EFX 98) will use a 2003 time frame for the experiment. The time had come for SBIRS/WM to become an active participant (versus listen only) in more exercises. SBIRS/WM also needed to add a DSP capability to properly represent the SBIRS system of systems to the warfighter.

An Integrated Solution

Just as SBIRS was developed to provide an integrated solution to the warfighter, the JNTF, SMC, and SBIRS Contractor (Lockheed Martin Federal Systems) joined forces to provide a simulation to meet the warfighter's simulation needs.

The Joint National Test Facility has provided support to exercises for several years utilizing their Portable Space Model (PSM) simulation. PSM provided a simulation of the current DSP system. Additionally, PSM provided a certified interface to the Tactical Event System elements, as well as DIS and other interfaces. The JNTF recognized an opportunity to merge the PSM and SBIRS/WM simulations to provide a simulation of the entire SBIR System (Figure 3).

The JNTF selected the SBIRS/WM and PSM merger as a pilot project to test a Product Line Architecture (PLA) concept being discussed with the Software Engineering Institute. Preliminary work began in June 1998 on a combined product called the Missile Defense Space Tool (MDST).

MDST and Product Line Architecture

The MDST is being developed to test and evaluate the feasibility of a PLA approach for software development at the JNTF. MDST will be developed in multiple phases to accommodate short-term requirements such as participation in EFX 98, and longer-term product enhancements such as incorporating upgraded models (e.g., SBIRS-Sim from the SBIRS Contractor). The concept is to develop a tool set that can be easily modified to each specific product.

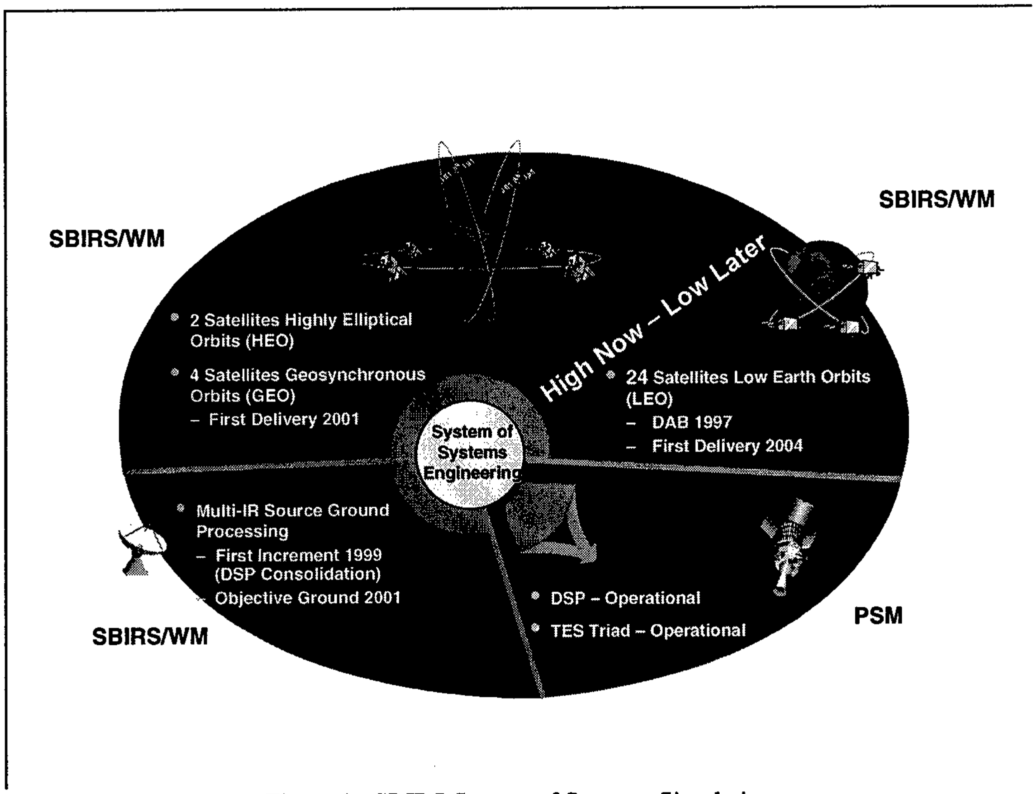

Figure 3. SBIRS System of Systems Simulation

A product will be defined based on the application of a set of core assets (such as MDST or personnel) brought together to meet a specific requirement or market application. An example of a possible product at the JNTF would be a wargame or exercise, not necessarily the simulation used to support these exercises (Figure 4).

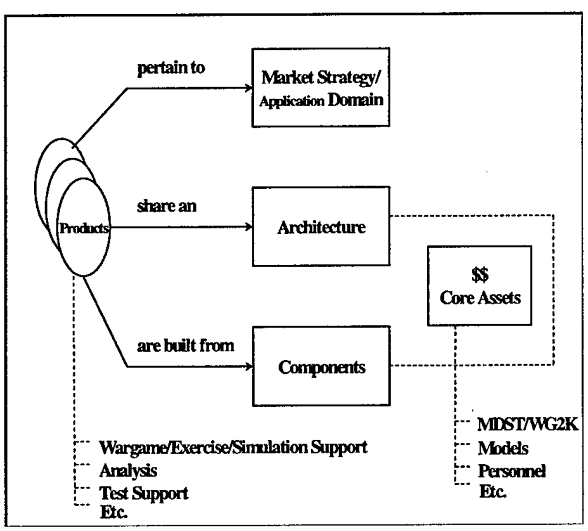

Figure 4. Product Line Core Assets

MDST will be designed to accommodate upgraded models, new hardware, and new interface requirements. For example, when a SBIRS low contractor is selected and an updated SBIRS Low model is developed, it can be integrated into the MDST framework and quickly injected into the on-going simulations and exercises supported by SMC and the JNTF (Figure 5).

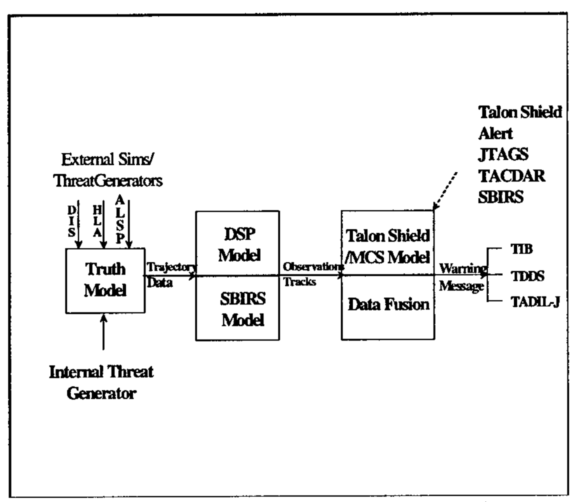

Figure 5. Conceptual MDST Phase 3 Architecture

One of the major goals is to develop a capability to provide the warfighter with the necessary simulation tools both quicker, and at a lower cost. This approach will allow SBIRS participation in EFX 98 – at least a year ahead of the planned participation in EFX 99.

The MDST will also provide an interface to the current TES elements, and will allow warfighters to analyze the impact of the transition from DSP to the new SBIR System using their existing systems. As the systems supported change or evolve, MDST will be able to quickly adjust to the changes. Their will not be a need to build a new end-to-end, stovepiped system, but rather replace the portion of the simulation tool that has been upgraded. Figure 6 shows some of the business goals for a PLA.

The Future

The JNTF, SMC, and SBIRS Contractor (Lockheed Martin Federal Systems) have teamed together to embrace the MDST and Product Line Architecture concept. Current discussions are under way to develop a Memorandum of Agreement that will provide the support and resources needed to make this concept work. A joint proposal was submitted to EFX 99 with an upgraded High Level Architecture (HLA) compliant model. The upgraded MDST will include an upgraded SBIRS High model and the addition of a Mission Manager model. This teamed approach will be able to capitalize on the initial JNTF participation in EFX 98, and provide significant enhancements to the MDST and to the warfighter. By teaming with SMC and the contractor building the SBIR system, the warfighter will have access to the most current and realistic SBIRS representations much quicker than ever before.

In addition to EFX 98 and 99, the JNTF has submitted a proposal to JWID 99 to use MDST as part of their demonstration. As part of the long-term PLA objectives, the JNTF will be evaluating other candidate systems for incorporation into its family of products. Discussions with the Space Based Laser and Space Based Radar program offices are on going to determine if the JNTF can assist in their Modeling and Simulation efforts. Figure 7 shows the proposed top-level architecture of the updated model referred to as SBIRS Automated Functionality for EFX (SAFEFX).

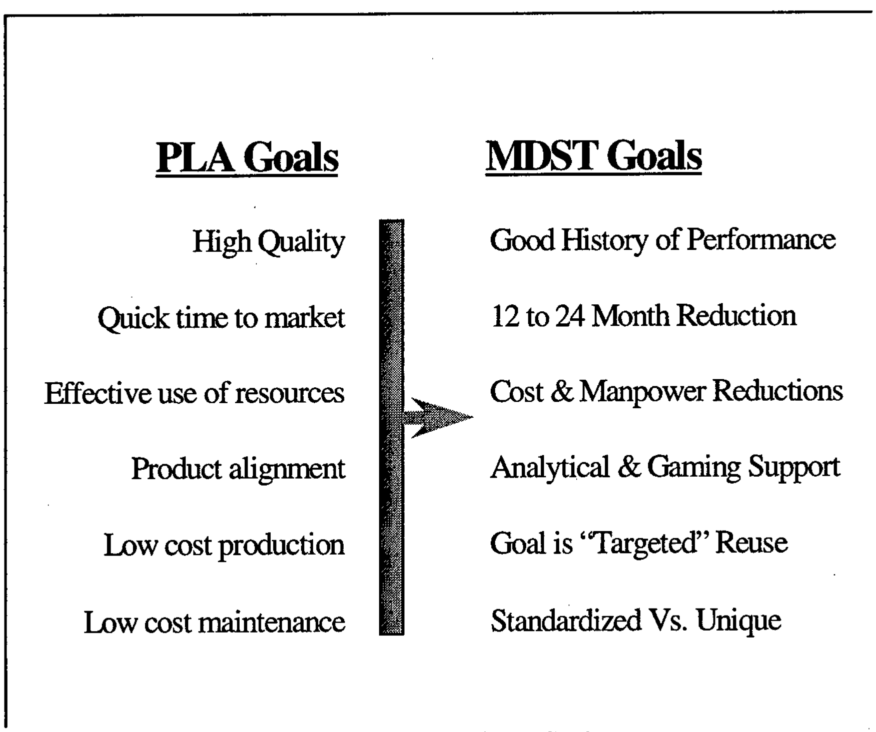

Figure 6. PLA Business Goals

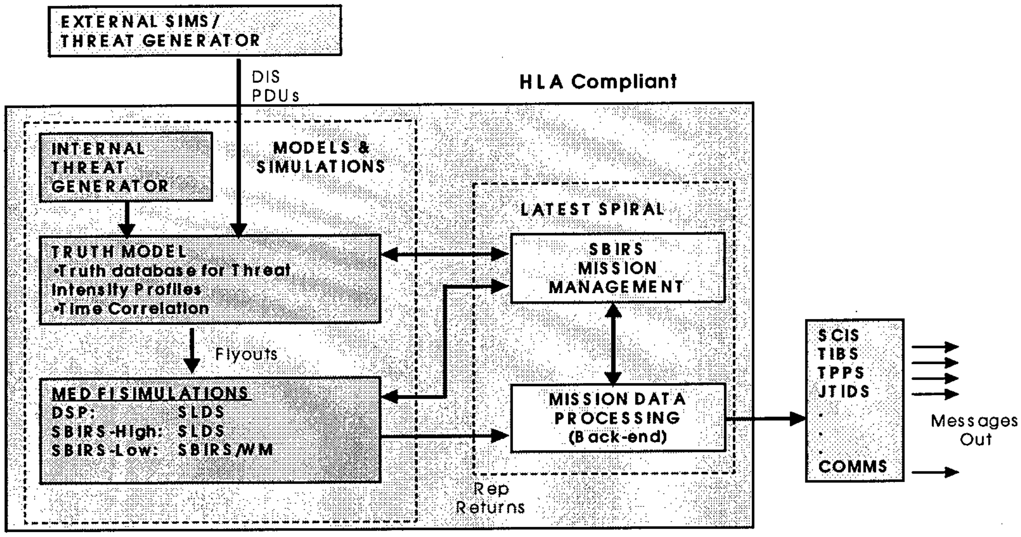

Figure 7. SAFEFX Functional Flow

Summary

Past successes have produced wide use of SBIRS/WM and PSM as stand-alone real-time representations of the government's SBIR Systems. However, these simulations must merge and continue to be upgraded to continue to meet the current and future needs of the warfighter for a realistic representation of the evolving SBIR System.

The Product Line Approach being pursued by the JNTF, combined with the teamwork, support, and resources provided by the SMC and SBIRS Contractor will provide the warfighter of today and tomorrow with a flexible, realistic, and quality simulation tool. As the SBIR System evolves, MDST will also evolve and keep pace, and provide the most current representation possible at an affordable cost.